RANDOM LINES.*

BY R. L. MORRISON, C. E., KNIGHTSTOWN, IND.

GENTLEMEN: Had there been any ready method of computation of departures, suitable for work in the field laid down in any of the text books on surveying—in the manuals or engineers' pocket-books—in Molesworth, Haswell, Trautwine, Nystrom or Burt's "Key to Solar Compass," there might have been no occasion for the reading of this paper. With incomplete exceptions, such as the short rules and table in Burt's "Key," published in 1854, and possibly others in manuals published since, which I have not seen, the subject of random lines has been left unnoticed. This is much as the books leave the truth in reference to triangles, viz., *that the line between the middle points of any two sides of any plane triangle is parallel to the third side, and is equal in length to half of it.* The reason why text-books have so carefully refrained from any mention of this fact was, for a long time beyond my comprehension, for it is absurd to think geometers had never made note of it. About ten years ago I stumbled upon it, and thought I had really found something. It has taken nearly all the years since for me to fully appreciate the utter insignificance of the discovery. They may have omitted to mention it because it was so extremely apparent that it would occur at once to the mind of every investigator! Be that as it may, let pupils who do not catch it at once be "bored for simples," if you choose, yet the fact remains that such an apology for failure to insert will not apply to the authors of the pocket-books mentioned, for insignificant items by the score swell out their volumes and are welcomed, in place, as entertaining or useful in assisting the memory to recall points almost forgotten. The County Surveyor would, doubtless, also welcome instructive items relative to random lines.

For the purpose of assisting those surveyors who may not have given the subject so much attention, as an aid to tiresome mental work in the field when tables may not be at hand: to remove the cause of much possible inaccuracy, and because of the failure of the published works to supply the need, have I ventured to furnish you with reliable and simple rules for field practice on random lines. I hope the older surveyors present will pardon me for demonstrating matters as to the process of their formation, which they may already so thoroughly understand.

The old text books on surveying give the departure 2¼ links, in distance of 80 chains (1 mile), for an angle of 1 minute; and it is now my purpose to show you what each member could as readily show himself, to wit.: How near 2¼ links departure is to the absolute truth. "The radius of a circle being 1, the semi-circumference is known to be 3.1459265358979. This being divided by 180 and 60, or at once by 10800 gives .0002908882086657 for the arc of 1 minute. Of so small an arc, the sine, chord and arc differ almost imperceptibly from the ratio of equality."—Legendre.

Now, in order to simplify the discussion, I shall here consider a link as if it were the unit instead of only the hundredth part of the unit. The sine, then, for arc of 1 minute, for 1 chain distance, expressed in links, will be .02908882086657, and for 80 chains it will be 80 times that much, or 2.327105-66932560.

2¼ links is..... .....2.333333333333333
Natural sine arc 1′ for 1 mile as above.....2.327105660932560

The difference is. 0022767400773

or say $\frac{1}{100}$ of a link, or .06 of a tenth of a link. This is nearly the sixteenth part of a tenth of a link as the difference for each minute of angle in a distance of 1 mile. Up to 1°, however, or 60 times the above difference, the difference is less than four-tenths of a link, and it is found from the carefully calculated tables of the books (the departures being given for but two places of decimals) that the departure for distance 40 chains, and for angle 1°, does not vary in the slightest particular from the departure worked out by the short method given below, the rule for which is made by assuming that 2¼ links is the true sine of angle of 1 minute in 1 mile. It is therefore unnecessary to use the long-drawn-out fractions where simpler forms can be substituted without inaccuracy.

If, then, the difference for 1° and 1 mile is four-tenths of a link, for 2° it would be eight-tenths link, therefore the short rules given below hold good for all angles up to 1° only. When angles are larger than 1° they pass out of the range of angles for ordinary random lines. Sometimes, however, in field work, larger ones are unexpectedly met with, and it is just here the importance to the surveyor of having at hand a ready method of computation becomes apparent. Such angles may be correctly and almost instantly computed up to 4° by General Rules A and B.

WHEN MINUTES OF ANGLE ARE GIVEN, TO FIND LINKS OF DEPARTURE.—If 2¼ links be taken as the departure for one minute in 80 chains, for 40 chains there will be 1½ links; *i. e.*, 1 minute=1½ link; therefore, the

Rule for 40 Chains.—To the number of minutes add ½ to get number links departure. Good for all angles up to 60 minutes.

[This rule I do not find anywhere, though it would be strange if it had not sooner been published.]

General Rule (A).—Multiply .0291 by given distance in chains and links, then multiply by given number of minutes to get number of links of departure.

Good for all angles up to 240 minutes.

Example.—The angle of two lines starting from the same point is 240 minutes. How far apart should they be in 100 chains?

.0291×100×240=698 links.—Ans.

NOTE.—In cases where extreme accuracy is desired, a proper allowance can be made for the difference in length of the random and the true line, equal to the versed sine of the included angle. In distance of 40 chains and angle of 4°, it is $9\frac{76}{100}$ links; *i. e.*, the true line will be 9¾ links longer than the random line if the right angled departure be projected from the latter line; if it be from the true line, however, the versed sine becomes subtractive from the measured distance. For 3° the versed sine, 40 chains distance, is 5½ links; for 2° it is 2½ links; while for 1° it is scarcely ½ of a link. I have fixed upon 4° as the highest limit of angles necessary to be considered in a treatise on random lines.

Short Rules for Special Distances.—Good for all angles up to 60 minutes.

For 40 chains—Add ½ to the number of minutes to get number of links of departure.

For 20 chains—Add ½ to the number of minutes and divide by 2 to get the number of links of departure.

For 10 chains—Add ½ to the number of minutes and divide by 4 to get the number of links of departure.

For 1 chain—Add ½ to the number of minutes and divide by 40 to get the number of links of departure.

General Short Rule.—Good for all angles up to 60 minutes.

Multiply the result obtained as above for 1 chain by any given distance in chains and links to get the number of links departure for such distance.

Example.—Given distance 18.35 chs., angle 24 minutes. Required links of depature?

24 + 4 = 28, ÷ 40 = 0.7, × 18.35 = 12.845 links.—Ans.

When Links of Departure are given, to find Number of Minutes of Angle.—In the equation 1½ link = 1 minute, the value of 1 link, expressed in minutes, must be obtained. Then if 1½ link = 1′, ⅔ lk. = 1′, or ½ lk. = ½′, or ⅓ lk. = ⅓′, *i. e.*, 1 lk. = ⅔′, or ⅔ lk. = ⅔′, where both terms are in the same denomination. Hence the

Rule for 40 Chains.—From the number of links departure subtract ½ to get number of minutes of angle. Good for all departures up to 70 links.

[This rule is given in Burts "Key" without explanation of its formation. His limit is 200 lks. per mile].

The general rule, which I do not find stated anywhere, is as follows, viz:

General Rule (B.)—Multiply distance in chains and links by .0291 and divide product into the given number of links, to get the number of minutes of angle.

Good for all departures which do not produce angles greater than 240 minutes.

Example.—The departure of two lines starting from the same point in a distance of 100 chains is 698 links. What is the angle?

.0291 × 100 = 2.91, 698 ÷ 2.91 = 240′.—Ans.

Reference to traverse table for distance 100 and angle 4° will show the correctness of general rules A and B in the examples given.

Short Rules for Special Distances.—Good for all departures which do not produce angles greater than 60 minutes.

For 40 chains—From links departure subtract ½ to get number of minutes of angle.

For 20 chains—From 2 times links departure subtract ½ to get number of minutes of angle.

For 10 chains—From 4 times links departure subtract ½ to get number of minutes of angle.

For 1 chain—From 40 times links departure subtract ½ to get number of minutes of angle.

General Short Rule.—Good for all departures which do not produce angles greater than 60 minutes.

Obtain result for distance of 1 chain, as above, and divide it by any given distance in chains and links, will get the number of minutes of angle.

Example.—Given distance 30 chains, departure 21 links. What is the angle?

(21 × 40) − ½ = 840 − 120 = 720, ÷ 80 = 24′.—Ans.

From the rules here given tables for instant reference can be constructed by any surveyor to any desired extent of completeness; or he can, without tables and without loss of time or danger of inaccuracy, make such computations in the field as may be necessary for any random line.

*Remarks on methods of computing minutes of angle from the number of links of departure and, vice versa, departure from angle, together with an extraneous observation on triangles. From a paper, the main part of which was read before the Indiana Association of County Surveyors and Civil Engineers at their second annual meeting in Indianapolis, Jan. 18, 1882.

ELECTRICITY VERSUS GAS.

About five years ago I pointed out that land would fall in value. It seemed to me evident that this would be the case, because larger and larger tracts of Western prairie were each year being converted into great corn farms, and the means of transport of this corn to our ports were each year rendered more easy. No one, however, believed me before the event proved that I was right, for one of the peculiarities of the English mind is, that it can never realize that what is will ever cease to be, until the "will be" has become the "is."

When Edison made his discoveries in electric lighting, again I raised my voice, and said—or, to put it more accurately, again I raised my pen and wrote—that the wise who held gas shares would do well to sell them. Edison's invention was not perfected. Gas directors jeered at it; it would never be more, they said, than a pretty theory; and even if it were to vanquish gas as a lighting medium, the companies would sell as much gas as they do at present for heating purposes, and this, with the sale of their "residual products," would secure to them as good profits as heretofore. Now, I was as well aware as others that the idea of lighting by electricity had not as yet assumed a clear, practical form, but I knew that the minds of so many would be devoted to giving it that practical form, that in the end they would succeed; while, as to selling gas for heating purposes and selling "residual products," I had calculated the results and knew what they were.

Let those who hold the shares of gas companies ponder over the following facts and figures. If they regard them as incorrect then let them keep their gas shares. If, on the other hand, they arrive at the conviction that they are correct they will take advantage of the folly of the mass of mankind and accommodate some fool with their shares before the collapse comes.

The mode in which electrical light is produced is very simple and can easily be comprehended when explained in plain and unscientific language. If you move a wire near the poles of a magnet, backwards and forwards, along what are called its lines of force, a current of electricity is attracted to the wire, and runs from one end of it to the other, provided there be a complete circuit. The strength of the current is in proportion to the size of the magnet and to the velocity with which the wire is moved across the "lines of force." Having got a magnet and a wire, the next thing, therefore, is to adapt motive power to them, which moves the wire quickly—that is to say, to a steam engine. The engine, wire and magnet together, then, form a machine which is called a "generator." With its aid, a stream of electricity is thrown into the wire. Now, if the wire be cut at any place, and then the interval between the two points be bridged over with a filament of carbon, the electricity passing through the carbon becomes incandescent. This constitutes the incandescent lamp. The carbonized filaments are enclosed in globes of glass in which there is no air, and in which, consequently, the filament lasts for several months without being destroyed. There are other systems, all based upon one principle and called "the arc," in which the electricity leaps from one stick of carbon to another, and in which the sticks burn like candles. In street lighting the arc is used, and, light for light, it is cheaper than gas. In the city the electric companies that light the streets are paid what the gas companies were, and for this they supply four times as much light. Gas is used to work the generators, but the amount of gas which would maintain a light of 12-candle power, employed in turning a generator, produces an arc of 1,600-candle power. If the same engine were employed to supply the incandescent lamps, the same quantity of gas would produce 12-candle power lamps, with an expenditure of a sixteenth part of the gas now requisite for this. The reason of this is that incandescent lamps have to be worked at a much lower temperature than arc lamps.

Electric light supplied to houses ought not to be, even in the present condition of the light, dearer than gas. Mr. Edison is now laying down 500 miles of electric light mains in New York City, and he will light every house with his incandescent lamps at the price which the owners are now paying to the gas companies. As a matter of fact, however, the light can be produced, as soon as mains are laid down, at a far less cost than gas.

The present condition of the electric light in London is: Streets are now being lighted with it at one-fourth of the price of gas; incandescent lamps can be introduced into every room of any house so soon as the mains are laid; there can be

a separate meter to each house; the lamps can be separately lighted, and put out by turning a cock; if one light goes out, no other one is affected; the sub-division is so complete that there is no glare, and yet a room with incandescent lamps is far more brightly lighted than with an equal number of gas lamps; and an equal amount of candle-power produced by electricity is cheaper than an equal amount produced by gas. In addition, the electric light has no odor, it does not vitiate or heat the air, nor does it, like gas, tarnish paint and decoration.

Are we then seriously to believe that electricity will not replace gas for lighting purposes? When railroads were in their infancy there were many who refused to believe that the public would seriously prefer them to the good old coaches. Yet the coaches have disappeared in favor of the railroads. So it will be with gas. We use this foul product because its advantages have outweighed its disadvantages. We are, however, not blind to the latter. If we can find something which will secure to us still greater advantages, and which will be without its disadvantages, can any one suppose that we are so enamored with the heated atmosphere, with the foul smell, and with the destructive properties of gas, that we shall continue to light our rooms with it?

In order to realize what a gas company is, and what its prospects will be when electric light is substituted for gaslight, it is only necessary to analyze the accounts of a company, and as the Gas-Light and Coke Company is the most important London gas company, I will take its published accounts for 1880 in preference to any other.

This company has a capital consisting of debentures, and of various denominations of shares, in all amounting to £9,277,122. Its revenue for the year was £2.612,566, derived from the following sources: Gas, £1,984,019; residual products. £565,480; meters, £37.813, and sundries £5,260. Its expenses were £1,712,656. and consequently its net revenue were £899,910. The capital is probably about £3,000,000 above the real amount for which all its plant might be brought into existence, and its net revenue might be increased by about £50.-000 were its resources economically administered, for in its debtor account I see that the directors receive £7,000, its law expenses are £4,669, its bad debts are £11.871, its collectors receive a commission of £24,707, and its superannuation and annuties amount to £17,969, while all other items are upon the same astounding scale.

It is clear that were the Company to pay 5 per cent. all round on its capital and on its debentures, its profit would not be too large a one. This it might do, were its net revenue reduced by £463,-856, and, as it receives for gas £1,984,619, it practically receives from gas consumers about 9d. per thousand cubic feet above what it ought to; and, were the works the property of the local authorities, and made with capital obtained at 3½ per cent., its present charges are about 1s. per thousand cubic feet beyond what would be required. In these estimates, I accept the preposterous capital and the preposterously wasteful annual expenditure of the Company, although, as I have already said, both are excessive.

Now, let us see what would be the effect on the company of the substitution of electricity instead of gas for lighting purposes. To produce the electricity, one-sixteenth portion of the gas now used for lighting would be required. Therefore, if the company were to depend upon this income it would be ruined. It would consequently be obliged to endeavor to sell its gas for heating purposes. About the financial effect of this to a company much nonsense is talked by chairmen and directors of companies. It is said that the demand would be so great that the saving in purification would be so enormous, and the profit from the residual deposits could be so increased that the profits of the companies would be the same as they are now. A few considerations and a few figures will dispel this illusion.

A gas company has now to produce gas free from impurities and with a 16-candle lighting power. It sells this gas at 3s. 2d. to 3s. 4d. per thousand cubic feet, because it has a monopoly, and because, even at monopoly price, gas is the cheapest illuminating power now on sale. If it were to sell for heating purposes it would have to compete with coal, and would have, consequently, greatly to reduce its selling price; moreover, it would have entirely to give up selling for lighting purposes, for the purified gas and the unpurified gas obviously could not pass through the same mains. I do not myself believe that gas ever will be extensively used for heating purposes, because habit in these matters is everything, and it will be long before the habit of open coal fires disappears. But I will assume that double the amount of gas is sold for heating purposes that is now sold for lighting and heating purposes, and that this is brought about by a reduction of one-half on the cost. The debit account would be reduced by £47,988 for purification, and increased by £907,086 for double the amount of coals, and by £163,877 for carbonizing, and would therefore be £3,383,563, instead of £1,712,650. The credit account would be increased by £586,180 for residual products, making it £3,519,602, instead of £2,612,566. Consequently the net revenue would be £136,089, instead of £899,910. It will be observed that in this estimate I make no allowance for the interest on new capital requisite to increase the works so as to double their production, or for an increased staff of engineers, etc., all these being supposed to be met by economy in the present wasteful revenue expenditure. Moreover, as the substitution of gas for coal would be very gradual, and probably never could take place to any extent, were not the price of gas reduced by three-quarters instead of one-half, it is clear that the condition of the company, when electricity is in general use for lighting purposes, will not be nearly as prosperous as the above calculation supposes.

There are no valid patents that stand in the way of producing the electric current, connecting it with lamps in the streets and in houses, and making the arc and the incandescent lamps. If the right to lay mains under the streets be granted to any particular electrical company, that company would have a practical monopoly, for it is clear that it would be impossible to allow rival companies to take up the streets at their pleasure. No company should, therefore, be given these powers. For years we have regretted that the supply of gas has been in the hands of private companies. These companies have been allowed to charge rates to secure to them a net 10 per cent. profit on outlay, and they have enjoyed a monopoly. The consequence has been that the outlay has been reckless, that revenue has been squandered because there has been no control over it by the householders who have had to pay for it, and that the companies and their officials have regarded their customers much as a feudal lord in the middle ages regarded the wretched serfs attached to the glebe. We must not again fall into the same error. Electric lighting must be for householders and by householders. The amount necessary for plant and working capital must be raised at 3¼ per cent. on the security of the rates, and the lighting of the metropolis must be in the hands of the representatives of the ratepayers. We have, alas, no metropolitan municipality. The only body that can take this matter in hand is the Metropolitan Board of Works. What it ought to do at once is to appoint a commission of men of science and of practical business men, who would report upon the amount necessary to lay electric mains, to distribute generators, etc., and also the price that would have to be charged for the supply of the light to cover interest on outlay, depreciation and working expenditure. Having acquired this knowledge, it should bring a bill into Parliament in the session of 1882 to acquire powers to light with electricity the whole of the metropolis under its jurisdiction.—*London Truth.*

CORRESPONDENCE.

WIND PRESSURE ON BRIDGES.

CHIEF ENGINEER'S OFFICE,
CHICAGO & ALTON R. R.,
CHICAGO, Feb. 25, 1882.

EDITOR ENGINEERING NEWS:

It is with regret that I have been obliged, through press of business, to leave unanswered until this late date the requests made to me to publish stress-sheets, showing the percentages of increase due to wind pressure in the stresses in the various members of a through and of a deck bridge, which, in my communication in ENGINEERING NEWS of Aug. 20, 1881, I signified my willingness to do.

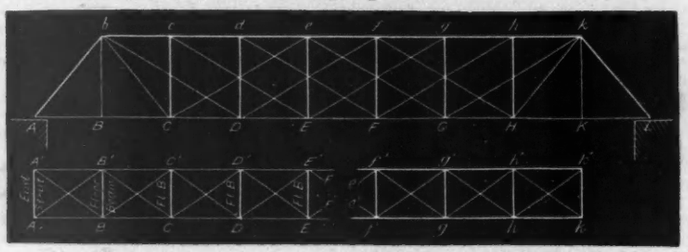
Since it is universally acknowledged that the effect of wind upon a bridge is to increase the stresses in some of its members, it remains to be determined in which members the percentages of this increase are sufficiently large to merit being taken into consideration. There being no law fixing that percentage above which the increase must invariably be taken into account, the standard must be fixed in each case by the engineer. This is, therefore, a matter of judgment. In this office we deem any increase worthy of consideration.

The fact that it takes nearly three times as much work to take the wind stresses into consideration by the method given in ENGINEERING NEWS of Aug. 20, 1881, as it does to compute the stresses due simply to folling and constant loads, may lead some—especially contractors filing large numbers of stress-sheets in competition with others—to consider that it is better and cheaper, in point of time and labor saved, for them to either neglect altogether the stresses due to the action of the wind, or else, when an increase of section to withstand wind pressure is called for in the specifications, to simply guess at the amount necessary. Such arguments, however, do not impeach the method, nor do they show that the required increase of section can be obtained by the "rule of thumb" so accurately as it ought.

I have the pleasure of submitting three condensed stress-sheets, each for a span of 160 ft. center to center of end pins, and all having the

STRESS SHEETS, SHOWING PERCENTAGES OF INCREASE IN STRESSES DUE TO WIND PRESSURE.

Through Span.



TENSION.

NAME.	MAXIMUM STRESS. Without wind pressure. Lbs.	MAXIMUM STRESS. With wind pressure. Lbs.	Percentage of increase.
A B	107,544	L 116,464	8.2
B C	107,544	L 141,880	31.9
C D	161,316	L 223,674	38.6
D E	215,108	L 296,134	37.6
E F	268,870	L 362,210	34.7
B b	45,339	L 50,364	11.0
C b	97,178	L 108,332	11.4
D b	86,875	L 95,768	10.2
E c	70,327	L 78,128	11.1
F d	33,096	L 35,280	6.6
G e	22,054	L 23,520	6.6
H f	11,032	L 11,032	.....
K g		.....	.....
k k'	.....	7,284	
h g'		4,856	
g f'		2,428	
f e'		.....	
B A'		35,676	
C B'		27,748	
D C'		20,811	
E D'		14,865	
F E'		9,910	

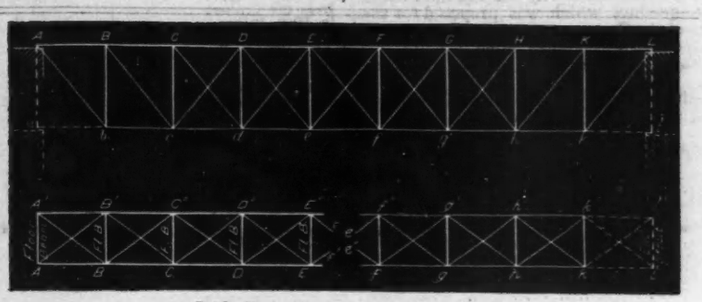
COMPRESSION.

NAME.	MAXIMUM STRESS. Without wind pressure. Lbs.	MAXIMUM STRESS. With wind pressure. Lbs.	Percentage of increase.
A b	210,918	L 238,825	13.2
b c	215,108	L 238,948	11.0
c d	268,870	L 293,480	9.1
d e	268,870	L 290,020	7.8
e f	268,870	L 288,290	7.2
C c	45,361	L 50,391	11.0
D d	21,347	L 22,756	6.6
E e	14,233	L 15,170	6.6
k k'		5,957	
h h'		5,106	
g g'		3,404	
f f'		1,702	

same number of panels. One is a through Whipple truss, and the other two are deck Pratt spans; one of the latter being swung from the top chords, the other from the bottom chords. According to the sheets the maximum stresses in some of the members of a given span occur in the leeward truss, while at the same time the maximum stresses in other members occur in the windward truss. Thus, in the case of the deck span swung from the bottom chords, the maximum stresses in the bottom chords, main ties and posts are found in the leeward truss, while those in the counterties and top chords are in the windward truss. This disposition of the maximum stresses varies with the style of bridge, *e. g.*, the maximum stresses in the posts of the deck span swung from the bottom chords occur in the leeward truss, while those in the posts of the deck span swung from the top chords are found in the windward truss.

It is seen that the percentages of increase vary greatly with the style of the span. This is owing to the fact that it depends on the style of the span whether the stresses in a given member arising from wind pressure do or do not act in conjunction with each other and with the stresses due to the moving and the fixed loads. The maximum stresses in the chords do not necessarily occur in the center panel, but may be found in the panel next to the center one. The difference in the maximum stresses in the chords of the center panel and of that next to it is usually, however, very slight.

Mr. Cain in his communication in ENGINEERING NEWS of Oct. 29, 1881, remarks that the formula given by Mr. Gottlieb in your issue of Sept. 17, 1881, and indorsed by myself, is less accurate than that given Aug. 20. I still consider one formula as accurate as the other, since either can be transformed into the other by the proper substitution. (D in the formulæ given Sept. 17 $= g$ in those of Aug. 20, and $\frac{1}{2} g \frac{\tan. B}{\tan. L}$ in the former $= x$ in the latter.) As to the relative convenience of the two formulæ in practical work engineers may differ.



Deck Span Swung from Top Chords.

TENSION. COMPRESSION.

NAME.	MAXIMUM STRESS. Without wind pressure. Lbs.	MAXIMUM STRESS. With wind pressure. Lbs.	Percentage of increase.	NAME.	MAXIMUM STRESS. Without wind pressure. Lbs.	MAXIMUM STRESS. With wind pressure. Lbs.	Percentage of increase.
		L				W	
b c	131,752	125,504	.....	*A B*	131,752	159,900	21.3
		L				W	
c d	230,566	233,552	1.3	*B C*	230,566	279,825	21.3
		L				W	
d e	296,442	302,552	2.0	*C D*	296,442	359,775	21.3
		L				W	
e f	329,380	337,122	2.3	*D E*	329,380	394,750	19.0
		W				W	
A b	221,196	224,064	1.3	*E F*	329,380	394,760	19.0
		W				W	
B c	170,321	172,181	1.1	*B b*	177,800	180,096	1.2
		W				W	
C d	123,870	124,431	0.4	*C c*	133,350	135,072	1.2
		L				W	
D e	81,843	82,872	1.2	*D d*	88,900	90,048	1.2
		L				W	
E f	44,240	47,150	6.5	*E e*	44,450	45,024	1.2
		L		*k k'*		6 848	
F g	11,061	16,143	46.2	*h h'*		5,868	
		L		*g g'*		3,912	
G h	— 17,694	10,149	42.6	*f f'*		1,956	
		L		*A A'*		29,286	
H k	— 42,025	31,726	24.5				
k h'		8,367					
h g'		5,578					
g f'		2,789					
f e'		.....					
A' B		37,116					
B' C		28,868					
C' D		21,651					
D' E		15,465					
E' F		10,310					

Deck Span, Swung from Bottom Chords.

TENSION. COMPRESSION.

NAME.	MAXIMUM STRESS. Without wind pressure. Lbs.	MAXIMUM STRESS. With wind pressure. Lbs.	Percentage of increase.	NAME.	MAXIMUM STRESS. Without wind pressure. Lbs.	MAXIMUM STRESS. With wind pressure. Lbs.	Percentage of increase.
a b	.....	.....	.....			W	
		L		*A B*	131,752	144,004	9.3
b c	131,752	153,896	16.8			W	
		L		*B C*	230,566	252,007	9.3
c d	230,566	269,318	14.4			W	
		L		*C D*	296,442	324,009	9.3
d e	296,442	346,266	16.8			W	
		L		*D E*	329,380	355,010	7.7
e f	329,380	384,740	16.8			W	
		L		*E F*	329,380	355,010	7.7
A b	221,196	245,016	10.7			L	
		L		*A a*	200,025	221,580	10.7
B c	170,321	188,513	10.6			L	
		L		*B b*	177,800	196,960	10.7
C d	123,870	136,653	10.3			L	
		L		*C c*	133,350	147,720	10.7
D e	81,843	89,544	9.4			L	
		L		*D d*	88,900	98,480	10.7
E f	44,240	47,150	6.5			L	
		W		*E e*	44,450	49,240	10.7
F g	11,061	12,651	14.4				
		W					
G h	— 17,694	— 11,895	32.7				
		W					
H k	— 42,025	— 32,308	23.1				

The annexed stress sheets are based on the method for calculating wind-pressure stresses given by me in ENGINEERING NEWS of Aug. 20, 1881. The letters "L" and "W" in the columns of maximum stresses indicate whether the stress occurs in the leeward or in the windward truss.

Through Whipple Span.

Length of span, center to center of end pins	160	ft.
Panel length	17.78	ft.
Trusses apart, center to center of chords	17.5	ft.
Depth of trusses, center to center of chords	30	ft.
Rolling load per lineal foot	3,000	lbs.
Constant " " " "	1,500	lbs.
Surface exposed to wind by rolling load per lineal ft. of bridge	8	sq. ft.
Distance above top of stringer of center of gravity of rolling load	8.1	ft.
Total surface actually exposed by one truss to wind pressure	638	sq. ft.
Wind pressure per sq. ft	32	lbs.

The total surface exposed by both trusses to the wind, when span is covered with the rolling load, is taken at 50 per cent. greater than that exposed by the windward truss.

Deck Pratt Spans.

Depth of trusses center to center of chords	24 ft.
Constant load per lineal foot	1,400 lbs.
Total surface exposed by one truss to wind	550 sq. ft.
" " " " both trusses to wind	1,100 "

Remaining data same as for the Whipple span.

The percentage of increase in the moment on the floor beams is 5.5 per cent., that on the stringers 2.7 per cent., and the increase in the stress in the floor-beam hangers of the through span is 5.4 per cent.

E. J. WARD,
Asst. Engr. C. & A. R. R.

ADJUSTMENT OF GRADES TO CURVES.

NORTHERN PACIFIC RAILROAD CO.
CONSTRUCTION DEPARTMENT.
YELLOWSTONE DIVISION,
GLENDIVE, Mont., Feb. 18, 1882.

EDITOR ENGINEERING NEWS:

Having just read with great interest "Adjustment of Grades to Curves," by H. A. McClellan, Chief Engineer Nevada & Oregon Railroad, I think it may possibly interest some of your readers to see a formula to the same purpose already used for some years on the European continent.

The curve resistance, indeed, depends upon so many circumstances as wheel-base, construction and condition of rolling stock, radius of curve, condition and form of rail, play between rail and wheel, heightening of outside rail, velocity, and length of train, etc., that it is not at all surprising to find the many existing formulæ for curve resistance, derived as well from theoretical reflections as from practical experiments, differing—to say the least—so very much from each other.

Thus Hensinger von Waldegg, Chief Engineer in Hanover, gives in his "Handbuch für Specielle Eisenbahn-Technik" (Leipzig, 1877) as an average value of many much differing experiments the following as curve resistance:

Radius in meter.	Curve resistance in kilogram per ton.
600	0.5
500	1.2
400	2.3
300	4.0

Cuts says, at the same time, that this value probably is too high, and suggests that the following is more correct:

Radius in meter.	Curve resistance in kilogram per ton.
600	0.3
500	0.8
400	1.7
300	3.0

Scheffler gives (I don't remember in which of his books) the following practical formula, generally used on the European continent, for adjusting a grade to a curve:

$$\frac{1}{x} = \frac{1}{n} - \frac{1}{1.31\,r}$$

$\frac{1}{x}$ being grade through curve in resistance = the grade $\frac{1}{n}$ on straight line, and r being radius in meter. Taking r in feet instead of in meter, the formula will be:

$$\frac{1}{x} = \frac{1}{n} - \frac{1}{0.4\,r}$$

which gives the equivalent grade in feet per 100 feet $= \frac{250}{r}$

The difference between Hensinger von Waldegg's statements of curve resistance, above mentioned, seems to show that it is of no use to take into consideration the difference in gauge within the limits now used, at all events, from the present standpoint of experience; and we may, therefore, without further, be entitled to compare the results from Scheffler's formula with the table by Mr. McClellan and with that by George L.

Continued on Page 76.

Engineering News.

GEO. H. FROST.....Proprietor.

Tribune Building, New York City.

JULIUS W. ADAMS, *Past President A. S. C. E.*, Editor.

S. D. V. BURR. .....Associate Editor.

SATURDAY, MARCH 4, 1882.

EDITORIAL ANNOUNCEMENTS.

Terms of Subscription.—To the United States and Canada, $4 per annum, including postage; all parts of Europe, $5, payable in advance. Remittances at the risk of the subscriber, unless made by registered letter or by draft, check or P. O. order, payable to Geo. H. Frost.

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Articles for Publication in the current number should be received at the office of publication not later than Thursday morning, and advertisements not later than Friday noon.

Correspondence upon subjects which naturally belongs to the province of this journal is solicited.

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NOTICES OF MEETINGS.

The American Water-Works Association.—The second annual meeting of the American Water-Works Association will be held in the City Hall, Columbus, O., on Tuesday, March 14, 1882. J. H. Decker, Secretary.

CROTON AQUEDUCT.

The construction of the Croton Aqueduct was commenced in April, 1837, and the water was introduced into the city in July, 1842, or five years thereafter. The High Bridge over the Harlem River was not completed until 1848, the water being carried over the river in the meanwhile by iron pipes.

The dimensions of the masonry aqueduct as built have an extreme height of 101 in., and extreme width of 89 in. The length from the dam over the Croton River to the receiving reservoir is 38 miles, and descends with a grade of 13¼ in. to the mile. The top of the dam, which is 40 ft. in height, is 166 ft. above the level of high tide. About one-eighth of the line of aqueduct is in embankment. The least flow of the Croton River was then estimated at 27,000,000 of gallons daily, while the capacity of the aqueduct was stated as between 60,000,000 and 70,000,000 gallons daily. The area of the Croton Lake is 400 acres, and its capacity of storage was 500,000,000 gallons above the level at which the aqueduct would discharge 35,000,000 daily. The cost was about $9,000,000.

Owing to the method of construction of the conduit when above the natural surface of the ground (where for economy of cost the supporting walls were laid of dry masonry) the effects of frost and irregular settlement have resulted in opening cracks in the masonry extending for long distances, and have occasioned great trouble and expense, and no little risk of complete failure. The irregular settlement at these places has induced changes in the level of the grade, so that, if much over 100,000,000 of gallons is passed daily through the conduit it becomes filled and subjects the masonry to a strain from the pressure of the head of water which it was not intended that it should undergo, and adds another element of danger to the above enumerated.

This it is which renders the construction of a new aqueduct with the least possible loss of time, and in view of the increasing demand for water, a necessity. This has long been foreseen, and the authorities for several years past have been engaged in examinations and surveys with a view to determining the location and character of a new structure which, safe from the contingency of failure, shall be of sufficient capacity to carry water for long years in the future of the city.

On the occasion lately of the report of Hubert O. Thompson, Commissioner of Public Works, to the Mayor, we noticed briefly the characteristics of the new aqueduct which was proposed for the conveyance of the Croton water, and now from the report of the Chief Engineer, Isaac Newton, we append some interesting notes of the proposed work.

The existing storage resources on the Croton water-shed, natural and artificial, are as follows:

	Gallons.
Boyd's Corners Reservoir	2,727,000,000
Middle Branch Reservoir	4,004,000,000
Lake Mahopac	575,000,000
Lake Kirk	565,000,000
Lake Gleneida	165,000,000
Lake Gilead	380,000,000
Lake Waccabuc	200,000,000
Lake Tonetta	50,000,000
Barrett's Pond	170,000,000
China Pond	105,000,000
White Pond	100,000,000
Pine Pond	75,000,000
Long Pond	60,000,000
Peach Pond	230,000,000
Cross Pond	110,000,000
Haine's Pond	25,000,000
Reservoir on east branch of Croton now under construction	4,500,000,000
Total gallons	14,000,000,000

The following table shows the rain-fall and the average daily quantity of water running in the Croton River:

Year.	Rain-fall at Boyd's Corners Reservoir.	Average daily flow of the Croton River at Croton Dam.	Percentage of rain-fall running in the stream.
	Inches.	Gallons.	Per cent.
1866	51.77	440,705,558	51
1867	50.77	541,318,397	65
1868	50.33	600,524,104	74
1869	48.36	456,575,841	58
1870	44.63	347,935,318	47
1871	48.94	357,175,341	45
1872	40.74	307,208,408	49
1873	43.87	444,236,877	67
1874	42.37	427,638,306	63
1875	43.66	425,021,738	59
1876	40.68	367,872,936	56
1877	46.03	346,503,178	45
1878	54.14	462,854,308	52

In 1875 surveys and estimates were made under the direction of Gen. Fitz John Porter, having in view the erection of a dam on the Croton, north of the present dam, at an elevation of 30 ft. above the latter, from which two lines were surveyed, one passing down Sawmill River, the other, branching from the first, passes down the valley of the Bronx River. The first line was 14 miles of the distance in tunnel and the latter 10 miles of tunnel. For comparison with these two lines we have the line as proposed by Mr. Newton, which taps a reservoir on the Croton 4½ miles below the present Croton dam, formed by erecting a masonry dam 185 ft. in height and storing above the flow line of its aqueduct near 33,000,000,000 gallons, thus dispensing with any further storage reservoir on the Croton basin. The line is nearly direct from this reservoir as proposed, to the High Bridge, being but $\frac{2}{10}$ of a mile longer than an air line between these points, and is for about 25 miles in tunnel. This line is known as the Quaker Bridge line, and would require 3½ years to construct, and together with the Sawmill and Bronx River routes, are compared in the following table in their general outline and cost, extended from High Bridge to Central Park Reservoir:

	Quaker Bridge plan, 1881.	Sawmill River plan, 1875.	Bronx River plan, 1875.
1. Total length, miles	31.35	42.31	41.17
2. Capacity in million gallons daily	250	150	150
3. Total storage provided by plan in Croton Basin, with dams just high enough to fill aqueduct, million gallons daily			
4. The same with dams, full height proposed, millions of gallons	32,000		
5. Total cost, including no provision for storage	$12,000,000	$13,093,414	$13,719,529
6. Total cost, including provision for 32,000,000,000 storage	14,000,000	*19,493,414	*20,119,529
7. Cost of providing 32,000,000,000 gallons storage in Croton Basin	2,000,000	6,400,000	6,400,000
8. Area of new lake, including present Croton Lake, acres	3,635	1,200	1,200

* The same as No. 5, with $6,400,000 for storage added.

Table of Comparison of the Plans which have been proposed for an aqueduct from Croton Basin, terminating at High Bridge.

	Quaker Bridge plan, 1881.	Sawmill River plan, 1875.	Bronx River plan, 1875.
1. Total length from the Croton to High Bridge, miles	26·51	36.52	36.08
2. Capacity, U. S. gallons in 24 hrs., millions	250	150	150
3. Total cost with no additional storage	$10,000,000	$9,191,989	$9,818,104
4. Total cost with 32,000,000,000 additional storage in Croton Basin	12,000,000	15,591,989	16,218,104
5. Cost per million of gallons of supply obtained, including 32,000,000,000 additional storage in Croton Basin	48,000	103,946	108,121

The Housatonic line is not embraced in the above, as in the event of its ultimate use, it would be an auxiliary to either project. There is much interesting matter in the report of the Chief Engineer of a general nature, aside from its special reference to the proposed new aqueduct.

SENSATIONAL SCIENCE.

A correspondent misunderstands our article headed "Sensational Science" in the last issue of the News, in that he mistakes the criticisms on sensational science as endeavoring to undervalue the labors of scientists performed in the interest of the public health, and very pertinently remarks "that the voluntary labors of our men of science in the direction of sanitary reform can have no other object than educating the people in principles which, if thoroughly understood and practiced, would tend to diminish very sensibly the ravages of preventable diseases."

In reply we would say that there can be but one opinion as to the value of modern scientific research in widening and extending the bounds of knowledge, and which calls for the hearty support of all interested, even in the slightest degree, in human progress; and we would be among the last to discourage or to disparage the labors of the true scientist in whatever line he may work. Without intending, however, any personal reflection on the scientists whose statements formed the basis of the article referred to, we must be permitted to remark that "they are not all Israel which are of Israel." The overshadowing importance attached to everything bearing on life and health, and the readiness of the average individual to seize and swallow, with but little discretion, whatever is offered for the benefit of either—and the votaries of no branch of science commanding so willing audiences as the sanitarians (and in none is the temptation for quacks to enter the ranks so strong)—that it cannot be denied that there is danger in the discovery that the art of making science sensational is a money-making one. And while this may be harmless as conducted by Mr. Richard A. Proctor, the astronomer, and others who could be named in some branches of science, it is far otherwise, however, in the one under consideration.

The various hypotheses for the spread of disease offer great facilities for this class of practitioners, and the germ theory, in particular, is the fruitful source of sensational writing. It is generally considered, by such as have acquired a right to an opinion on this subject, that it is more than probable no one of these hypotheses can be taken as true in all cases, but that there is a modicum of truth in each. Whichever theory, however, may be assumed as truth, experience has shown that, as an essential toward diminishing the ravages of disease, ventilation plays a most important part in modern practice; and in the treatment of the zymotic diseases, which are classed with the preventable, it is the sine qua non. Now ventilation is but dilution, and where this is applied in the proper place, we have the evidence that natural causes, so far from tending to increase the spread of disease, will, if properly availed of, furnish the most reliable means for staying its progress. Take the matter of sewer gas. It is undeniable that the putrefaction of animal and vegetable refuse produces a something which, if in sufficient *quantity*, and this is important to bear in mind, tends to plant the seeds of disease in various ways in the human organism. Now, whether this be a living germ, which as a species of parasite can multiply itself indefinitely under favorable circumstances, or whether it be of fungoid growth as was first supposed, and which gave the name to this class of diseases, science has established, and we think conclusively, that its generation is not spontaneous, but, "omne vivum ex ovo," and a vitiated condition of the atmosphere is essential to the incubation. What-

ever may be the process, it is here and at this time that ventilation is beneficial, and a surrounding of free oxygen is antagonistic to the development of the germ. Hence that the organic compound called disease germs, whatever it may be, shall be deprived of its fecundating principle, it is only necessary that free oxygen should be present in sufficient quantity to break up and destroy its organic constitution, and to rearrange its elements into inorganic forms, inocuous and free from any quality dangerous to human life. Nature has provided the means, and man is only required to give them full scope, and this is insured by providing copious dilution, whether of pure air or water, preferably of both.

We have no reason to believe, on the contrary, are free from any suspicion whatever, that Mr. Falkard, Prof. Doremus or Dr. Parker had any intention of needlessly alarming the public in reference to the dangers with which we are surrounded, and which, if of the magnitude stated by them, it would be almost hopeless for us to attempt to shield ourselves against. We would much prefer to believe that, with preconceived ideas of what scientific research *should* develop, their sight was dulled to the apprehension of what really were the facts. What Mr. Falkard says as to the germs of disease, the concurrent testimony of scores of distinguished scientists and experimenters disproves entirely That Prof. Doremus blew out a candle by the mere force of his breath through a sound Philadelphia brick. This we do not believe, notwithstanding the report is so circumstantial. And when Dr. Parker says that diphtheria was not known in this city until the introduction of the Croton water, and that "it was solely caused by bad air from sewers" we can only say that his memory is at fault, for it is the testimony of equally careful observers that, before the introduction of the Croton, the city was ravaged yearly by deadly epidemics, believed to have been invited by the defilement of the wells then in use, by sewage and fœcal soakage, and no such visitation has occurred since.

We are greatly indebted to indefatigable scientists for the *truths* their researches bring to light, and we accept their statements, each in his own department, with the humility which becomes laymen; but when they indulge in inferences and deductions as the necessary results of these truths, outside and beyond their specialty, we question their infallibility, and claim an equal right to an opinion. As an illustration, an invention is shown us whereby sewer-gas may be kept out of the house, and the inventor has fortified his claim by the opinions of an M. D. We accept this indorsement so far as to the fact that it is desirable to prevent such gases from entering the house, but as to the efficacy of a given machine to effect that purpose we may question the fitness of the M. D. for the decision, without in any way questioning his professional skill as a physician.

If the errors which a special scientist may commit in this direction were confined to the bare incident itself, it would be a small matter, but here comes in the danger to this community. A fictitious source of disease could well be met by an equally fictitious remedy, and together they would prove efficacious, not in diminishing the death rate perhaps, but in leading the public to believe that the inroads of a fearful disease can only be averted by the use of a patented article which it behooves all householders to provide themselves. The illustration is used of a patented machine as one of frequent occurrence, but the same principle is applicable to cases where the injury done is not merely one of needless expense to the individual householder, but where a needless alarm is created over a wide district and where the sole remedy offered is one so radical and sweeping, involving possibly almost a reconstruction of the entire district, that the individual is powerless and must look to the authorities alone for succor. In the meantime, and waiting the action of the latter, the householder must bide his time with such patience as he may, bearing the horrors of a lingering death to himself or family contantly before his eyes. This condition of things is what we would be understood as deprecating—being the natural consequences of what we regard as "Sensational Science" when applied to sanitary matters in this city.

DANGERS OF SEWER AIR.

On page 62, ENGINEERING NEWS, Feb. 25, in Sewerage of European Cities, by Rudolph Hering, the fact will be found stated that the sewage proper of Paris, France, is led in conduits to Gennevilliers below the city for purposes of irrigation, over an area of a thousand acres, and since the works were started in 1869 a village has sprung up (Gresillons) in the midst of the territory, wherein the death rate has averaged from 19.5 to 25.3. What significance, we would ask, is to be attached to this fact in an atmosphere reeking with foul odors?

RADIUS OF GYRATION.

We received a communication a few days since from an engineer of which the following is an extract:

"In using the formula for determining the strain per square inch on an iron column

Wherein R = strain per square inch
l = length of column in inches.
r^2 = square of least radius of gyration.

what method is recommended for finding the value of the least radius of gyration?"

Having had occasion during the discussion of the elevated roads proposed in a neighboring city a few years since, to compute the strength of columns, we now turned to "Rankine's Applied Mechanics" for the formula which we used on that occasion, and which we have always used in similar cases—the formula called Gordon's formula, based upon the well-known experiments of Hodgkinson and Fairbairn. Indeed at that date, specifications for bridge work called for the use of this formula. In our own experience we cannot call to mind a single instance wherein the use of a special formula for stress and strains was enjoined in drawing up specifications for bridge work, save in the computation of compression members and by this formula. We accordingly advised a correspondent in last week's issue that if r^2 in his formula was not the square of the least diameter, or the direction in which the column was most flexible, he should make it so. That is to say, for the ultimate strength of column on flat bases

$$P = \frac{fs}{1 + a\frac{l^2}{h^2}}$$ (Rankine's A. M., p. 362).

A card from J. H. D., of this date, very kindly suggests that this advice given by us was doubtless given hastily, and alludes to the advantages in the use of the radius of gyration.

We are constrained to say that this was not the case, however, but that the advice was given deliberately, with a knowledge that this affectation of precision in substituting a radius of gyration in the denominator of the second term of the equation had been in use, although Rankine in his A. M. makes no mention of it whatever in this connection; but in his rules and tables the above original formula of Gordon's is transformed into

$$P = \frac{fs}{1 + \frac{l^2}{cr^2}}$$, and a table is given for the values of

r^2, or the square of "radius of gyration," for the various sections of columns usually met in practice.

But Gordon's formula, in which the ratio of the length to the diameter, in the direction in which it is most flexible, is introduced, has the merit of carrying with it a principle—is simpler and more ready of use—and so far as our limited experience goes, judicious computations by means of it are as much to be relied upon as by any method which has been proposed. For in truth, the strains on a column, the resultants of the pressure upon which does not pass through the center of gravity of all of its sections (and the deviations from this axis must in most cases be very difficult of determination) cannot be determined with any precision by mere recourse to new nomenclature, and the possible errors under any system of computation must be allowed for in a factor of safety. In columns of complex angular sections there may be advantages in a recourse to the radius of gyration. We may be a little antiquated in our views of this, and if any of our readers will have the kindness to show the practical advantages growing out of the use of the radius of gyration in all cases in lieu of the diameter of least resistance to flexure in columns, with a practical illustration, we shall be extremely indebted to them, and though its practical value may be lost to us, to many of our readers not so wedded to their old ways and open to new light it may prove of incalculable advantage.

RECENT INVENTIONS.

A novel way of joining branch pipes with the water main is to provide the main pipe with an elbow-nipple opening from the side of the main and extending into the bore thereof, with an orifice of less diameter than the main. The opening in the elbow is arranged opposite the direction of the flow through the main, and in the center thereof, whereby the main current is at all times free to flow around the branch, while the orifice of the branch intercepts a column equal to its area.

A late invention relates to expansion joints for street-mains designed for steam-distributing systems for supplying cities, and it has for its object to dispense with slip-joints and large stuffing-boxes. The variations in the length of the main due to changes in temperature are compensated for by constructing the ends of the separate lengths of pipe with rigid disks or flanges, and with elastic disks bolted thereto, which permit expansion and contraction.

A new fire-annihilator apparatus contemplates holding chemicals in separate receptacles until required for use. Two inverted vessels are mounted on a frame over a common reservoir. The mouths of the vessels are closed by stoppers, which are held in place by fusible solder between them and the outer edges of the mouths. These vessels hold the chemicals necessary to the formation of a fire-annihilating gas, and do not discharge their contents into the common reservoir filled with water until the requisite temperature fuses the solder which confines the stoppers.

A novel sewer-trap consists of a spherical casing of transparent material provided with thickened threaded extensions at the points through which the two connecting pipes enter, and protect some distance into the interior of the casing. This construction admits of the connecting pipes being set vertical or horizontal, and also prevents siphonage. A light held behind the transparent globe allows of proper inspection.

A late invention in suspension bridges combines the suspension and cantilever systems; the former to carry the bridge structure, the latter the roadway and the moving load. The roadway is supported upon joints of the cantilever-stays in such manner that the links secured to the main beam communicate only an endwise thrust to the beams.

Another invention in suspension bridges has two or more cables passing over rollers on top of the piers, and under rollers fastened to the bottom of the bridge, and carrying a free weight attached to the ends of each cable. These weights and cables are to assist in carrying the bridge.

A new draw-bridge guard consists of horizontally swinging gates, secured to vertical posts which are actuated by intermeshing cogged segmental plates. These plates have slots that are engaged and operated by a pin on the bridge to move them.

Another draw-bridge guard has gates composed of two sets of vertically swinging bars, pivoted in posts at the side of the roadway. These bars are raised by a pitman pivoted to their inner ends, said pitman in turn being pivoted to a crank at one end of the rock shaft. This shaft has a corresponding crank at its other end so arranged as to be depressed by the draw-span as it closes. The bars drop by their own weight when the span is opened.

WASHINGTON, D. C. F. B. BROCK.

ENGINEERS' SOCIETIES.

ENGINEERS' CLUB OF PHILADELPHIA.

Record of regular meeting, Feb. 18, 1882:

President Rudolph Hering in the chair; 34 members and 2 visitors present.

The Secretary exhibited two specimens, contributed to the Club by Mr. Chas. H. Haswell, C. E., N. Y., one being a yellow brick 1¼ in. × 3¼ in. × 6¼ in., imported from Holland early in the last century, and removed by Mr. Haswell from the premises in Broadway, N. Y., known as "Washington's Headquarters;" and the other a piece of honeycombed marble from the "Grecian," stranded on Long Island in 1870 and recovered in 1877.

He also exhibited, on behalf of Mr. Strickland Kneass, a plan of Howell's Excavator and Distributor, the object of which is the reclamation of swampy land bordering on the sea coast, by conveying material from the beach in buckets on an endless belt to a hopper, whence it is spread over the low land by scrapers on another endless belt.

He also read interesting extracts from a very full account of the construction of Market street bridge, Philadelphia, published as an addendum to the "Memoirs of the Philadelphia Society for Promoting Agriculture," vol. 1, Philadelphia, 1808. The history of the pier construction and the difficulties encountered therein is of special interest.

Mr. Charles A. Ashburner exhibited a 100-ft. contour map, recently made by him, of McKean County, Pa., in which the space between contours is shown by tints, each 500 ft. of elevation being indicated by a separate color, in five bands—shaded from light to dark as the ground descends.

Mr. Ashburner pointed out on the map the route of the Bradford Branch of the N. Y., L. E. & W. R. R., which is being built from Alton south into the coal fields of Elk County. The difficulties which have for years baffled the engineer in locating a feasible north-and-south route through McKean County were explained. The present location was made by Mr. Oliver W. Barnes. The Kinzua Creek Valley is crossed by a bridge and viaduct, being built by the Phœnixville Bridge Company. It is reported that this bridge will be 305 ft. high, will consume 40,000,000 pounds of iron, will require 30,000 yards of masonry and will cost half a million of dollars.

Mr. Wilfred Lewis stated that his attention had been called to a table of "Logarithms of all Vul-

gar Fractions with Numerator and Denominator not exceeding 100, arranged in Order of Magnitude," by Sir Geo. B. Airy, Hon. Memb. Inst. C. E., for the determination of teeth of wheels for a required angular speed, and that he had arranged a table with special reference to wheels in ordinary use in his own practice, by means of which the result of every single combination could be determined.

The Secretary read a communication from Mr. E. H. Kellogg, City Engineer of Denver, Col., stating that the engineers of that place were about to organize a local society.

HOWARD MURPHY,
Secretary and Treasurer.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

The regular monthly meeting of the Society was held at its house, 127 East Twenty-third st., New York, on Wednesday evening, March 1, Mr. T. C. Clarke in the chair.

Amendments to the Constitution relating to the Fellowship Fund were adopted.

The following candidates were elected:

As Members.—John W. Andrews, Goldsboro, N. C.; George Burnet, Jr., Indianapolis, Ind.; William H. Martin, San Francisco, Cal.; Charles H. Prior, Minneapolis, Minn.; James L. Randolph, Baltimore, Ind.

As Associate Member.—William Watson, Boston, Mass.

As Junior Member.—Cassius W. Kelly, New Haven, Ct.

The Secretary presented a copy of a bill to be introduced in Congress authorizing the appointment of a commission to test metals and other structural materials. He also gave a report of the discussion on that subject, which occurred at the recent meeting of the American Institute of Mining Engineers, in which officers and members of this Society took part by invitation.

The following resolutions were adopted:

Resolved, That in the death of Alexander Lyman Holley, formerly Vice-President of the American Society of Civil Engineers, the engineering profession at large, no less than our own Society, has suffered a grievous loss. In him were combined not only the inventive genius to discover and successfully apply new methods of subduing the forces of nature for the benefit of mankind (as evinced in the great industries which have been developed under his direction), but a rare literary facility for arranging and distributing stores of information obtained through patient study of the works of others. By the example of his life, in his gentleness, his industry, his modesty, his deferential consideration of opposing counsels, combined with integrity, indomitable energy and power of work, the standard of our profession has been materially advanced, and a spirit of goodfellowship engendered, which has had the effect to weld in harmonious continuity of interest the several branches of a profession destined to play an increasingly important part in the advancement of civilization.

Resolved, That a committee of five be appointed to act in conjunction with similar committees which have been or may be appointed by the American Institute of Mining Engineers and the American Society of Mechanical Engineers in any further measures that may be deemed advisable in honor of the memory of our departed brother.

Resolved, That we offer to the family of the deceased the assurance of our earnest and respectful sympathy in their affliction.

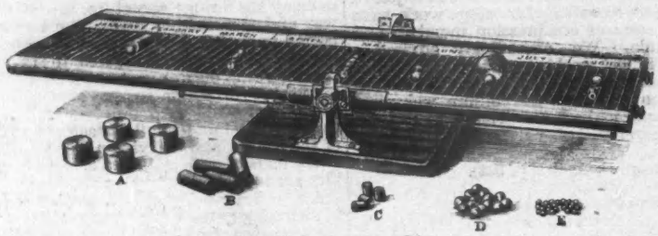
Resolved, That the Secretary be instructed to transmit copies of the above resolutions to the family, to the Secretary of the American Institute of Mining Engineers and to the Secretary of the American Society of Mechanical Engineers.

A paper upon the Averaging Machine, in its wider range and greater capacity, was read by Mr. Wm. S. Auchincloss, member A. S. C. E., its inventor. Reference was made to the machine described in a former paper (Transactions, vol. x., p. 135). That has now been remodeled, and is presented in a more compact shape. The ingenious method by which the weight of the platform is eliminated from the result of the work of the machine was exhibited and explained. This is accomplished by counterweights sliding automatically in tubes, so that in any position the unloaded platform is always in equilibrium.

Any combination of representative weights can then be placed on this platform at the proper points of the scale. By then drawing the platform to its balancing point, the location of the center of gravity will at once be indicated on the scale by the pointer over the central trunnion.

The weights may be arranged on a decimal system, with intermediate weights for closer working; or they may be made so as to express multiples or factors.

Each machine is provided with a number of



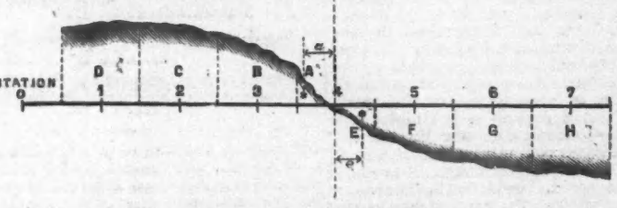
AUCHINCLOSS' AVERAGING MACHINE.

differing scales, divided suitably for various purposes. When the problem is one of time, the scale represents months and days; for problems of proportion the zero of the scale is at the center of its length; for problems for the location of center of gravity of a system from a fixed point, the zero is at one extremity of the scale, etc., etc.

The machine exhibited has 63 transverse grooves, which, by arrangement of weights, can be really made to serve the purposes of 252 grooves.

The machine is 29 in. in length, 9 in. in width and weighs 13 lbs.

With the machine can be found average dates, as for instance of purchases and of payments extending over irregular periods; also average prices, as for "futures" in common use among cotton brokers.



PROBLEM IN AVERAGE HAUL.

The problems of average haul, so often presented to the engineer, can be solved with ease and great celerity. Practical examples of the solution of other problems involving proportions or averages were given by the author.

THE COLORADO INSTITUTE OF ENGINEERS.

LEADVILLE, Col., Feb. 15, 1882.

Resolved, That to the scientific and technical papers in the United States, and to all papers in Colorado, the following notice be transmitted for publication, in order to make known the existence and objects of the Colorado Institute of Engineers, and to invite the co-operation of other scientific associations, journals and those interested in scientific investigations and industries.

NOTICE.

The Colorado Institute of Engineers has been organized by the civil, mining and mechanical engineers, chemists and metallurgists of the city of Leadville, Col., for the purpose of affording an exchange of scientific ideas; the professional improvement of its members; the advancement of mining industries; the fostering and encouragement of scientific research in the many fields which this country affords; the establishment of a library and reading-room, of technical works, periodicals, communications and original manuscripts; the collection of a mineral cabinet, and the creation of a central point of reference and union for its members.

Much care has been employed to make the initiatory steps in the formation result in the proper basis for a permanent and reliable association.

The encouragement which has been given warrants us in saying that we believe the success of the undertaking to be fully assured.

The organization was completed on Jan. 25, '82, and rooms secured for the Institute in the post-office building at Leadville, Col.

The regular meetings are held at the Institute rooms on the last Wednesday of each month.

All persons interested, visiting the city, are cordially invited to use the rooms of the Institute during their sojourn here.

Any further information desired can be obtained by addressing the Secretary.

THOS. W. JAYCOX, President.
FRANK L. SIZER, Secretary.
P. O. Box 248.

ENGINEERING CLUB OF RIO DE JANEIRO.

From the *Rio News*, of Rio de Janeiro, Brazil, we clip the following item:

The Engineering Club of this city has undertaken the organization of an annual congress of representatives from all the railways of the empire, to be held in the month of June. The plan includes delegates from the companies, administrations and fiscalization departments; also national and foreign engineers who wish to attend, and a commission appointed by the Engineering Club. The congress will be in session for one month, which will be divided into four sessions: 1, organization and choice of subjects for discussion; 2 and 3, discussion of these subjects; 4, reading or presentation of any works which the delegates and engineers may wish to bring before the congress, for which the first session made no provision. The club proposes to bear the expenses of the first congress and publish its minutes and other labors.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E.

Continued from page 67.

CCXX.—MORRISTOWN.

Morristown, New Jersey, in lat. 40° 48′ N., long. 74° 28′ W., on the Whippany River, a small tributary of the Passaic, is in a hilly district and is situated chiefly on a sandy promontory with steep slopes.

Settled in 1725, it was incorporated in 1865. Water-works were built in 1799 by a private corporation. The name of the designer of the works is not known. The water was taken from springs rising in the valleys of the gravel hills west of the town and collected in impounding reservoirs formed by dams of earth. Three reservoirs have been built from time to time, the last in 1880 under the direction of George W. Howell, C. E. This is the largest and holds 16,000,000 gallons. The others hold respectively 1,400,000 and 2,000,000 gallons.

Two 6-in. pipes, one of cast iron, the other of wrought iron and cement, conduct the water from the storage basins to a stone reservoir 70 by 200 ft. and 14 ft. deep, on ground 70 ft. above the level of the greater part of the city. In times of drought it is necessary to take a part of the supply from the river, by pumping with a Worthington steam pump erected in 1865.

In drawing from the storage reservoirs, the water is taken from near the surface and dropped through fine wire screens, to bring all the water in contact with the air.

Distribution is by 13 miles of cast-iron pipes, of from 6-in. to 3-in. diameter, with 70 fire hydrants and 600 taps. For hydrants the city pays $17 each per year; 60 meters are in use. Some wrought-iron and cement pipe were used at one time, but did not give satisfaction. Service pipes are of lead, of galvanized iron and of cast iron 2 in. in diameter. The last named are preferred.

The population in 1880 was 5,446, and the daily consumption about 200,000 gallons in the times of greatest use.

The capital stock of the company is $50,000. The cost of the works has been $138,000, including certain lands and water rights not yet utilized. There is a bonded debt of $50,000 at 6 per cent. interest. For many years prior to 1869 the stock was held by one person, and no records were kept. In 1881 the expenditures for all purposes were $8,800 and the receipts $15,000.

Henry C. Pitney is President, and Edward Pierson Secretary and Treasurer of the company.

CCXXI.—SIDNEY.

Sidney, Ohio, in lat. 40° 27′ N., long. 85° 18′ W., on the Great Miami River, is on a level plateau surrounded by hills. The surrounding country is rolling. Settled in 1820, it was incorporated as a city in 1850. Water-works were built in 1873 by the city, after plans of T. R. Scowden, C. E., taking the supply from Mosquito Creek, a small stream receiving the drainage of a considerable area of marshy and springy ground. A small stone dam across the creek diverts the water into a raceway 2 miles long, which conveys it to a

point where 29 ft. head is obtained, which furnishes power for driving Holly pumps, which deliver into the mains. A reservoir of 2 acres area supplies the pumps. The highest part of the city is 50 ft. above the reservoir. The ordinary pressure maintained at the pumps is stated to be 100 lbs. and the fire pressure 170 lbs. Five miles of cast-iron mains of 12-in. to 4-in. size, with 40 fire hydrants and 150 taps are in use. Lead and wrought-iron service pipes are used.

The population in 1880 was 4,250, and the daily consumption about 8,000 gallons.*

The works have cost $54.000. The cost was met by bonds bearing 6 per cent. interest, the interest and part of the principal payable annually in such proportion as to extinguish the debt in 20 years.

The expenses of maintenance in 1881 were $300, besides an annual rental of $800. The receipts were $560.

The name of the superintendent is not furnished.

CCXXII.—ST. ALBANS.

St. Albans, Vermont, in lat. 45° 47′ N., long. 73° 9′ W., is on a small stream emptying into Lake Champlain. It was incorporated as a village in 1859. Water-works were built by the village in 1873, after the plans of John T. Fanning, C. E., taking water from the stream.

A dam 400 ft. long and 28 ft. high, of earth, and 20 ft. wide on top, with inner slope of 2¼ to 1, and outer of 1½ to 1, and an embankment of 1,950 ft. long across low ground, create an impounding reservoir of 28 acres area, and holding 100,000,000 gallons, stowing the drainage of about 3 square miles. The reservoir is 336 ft. above the town.

Distribution is by 14 miles of wrought-iron and cement pipe with 54 fire hydrants, 37 gates and 500 taps. Five meters are in use. Service pipes are of galvanized iron. The head is so great that it is necessary to use a regulator on the mains. The population in 1880 was 7,201 and the daily consumption 600,000 gallons.

The works have cost $165,000, and the total receipts have been $46,000. The bonded debt is $156,000. The expenses in 1880 were $1,362.61 and the receipts $6,359.73. The works are managed by a board of five trustees; Marshall Mason is the Superintendent.

CCXXIII.—LOGANSPORT.

Logansport, Indiana, in lat. 40° 45′ N., long. 86° 22′ W., is on the Wabash River at the mouth of Eel River. The business part of the town is between the rivers and 40 ft. above them. Two miles back from the river the ground rises to a height of 200 ft.

Settled in 1828 it was incorporated as a city in 1838. Water-works were built by the city in 1876 after the plans and under the superintendence of Walter A. Osmer, C. E., taking the supply from Eel River, which in its course of 100 miles receives the drainage of a territory about 30 miles wide.

A dam of timber across the stream at the city gives a head used to drive a water wheel operating 4 Cope & Maxwell piston pumps, of 11-in. bore and 24-in. stroke, pumping directly into the mains. Auxiliary steam power is provided, but seldom used. The ordinary pressure maintained is 45 lbs., and the fire pressure 80 lbs. Distribution is by 9½ miles of cast-iron pipe, with 89 fire hydrants, 154 gates and 400 taps. Lead service pipes are used. There are 6 meters in use. The population in 1880 was 11,198, and the daily consumption 500,000 gallons.

The works have cost $132,000. The bonded debt is reported at $172,000, bearing 8 per cent. interest. The expenses of maintenance in 1881 were $3,000, and the receipts $6,900.

The works are managed by a board of three trustees, appointed by the City Council. Robert Johns was Superintendent and Engineer from 1876 to 1878, and William H. Schrier from 1878 to 1882. Terrence McGovern is Clerk to the Board.

CCXXIV.—ST. JOHNSBURY.

St. Johnsbury, Vermont, in lat. 42° N., long. 71° W., is in a hilly region, on the Passumpsic River.

Settled in 1787 it was incorporated as a village in 1852. Water-works were built by the village in 1876, after the plans of J. P. Flanders, taking the supply from the Passumpsic River, a timber dam across which worked a water power used to drive a Flanders pump delivering directly into the mains, with an ordinary pressure of 80 to 100 lbs. and a fire pressure of 100 to 125 lbs. per square inch.

The water is delivered to the pumps by passing up through 4 ft. of gravel. This filter is reported to give satisfaction. Distribution is by 8 miles of cast-iron pipe of 12 to 4-in. diameter, with 77 fire hydrants, 27 gates and 303 taps. Service pipes are of wrought iron.

The population in 1880 was 5,806, and the daily consumption 250,000 gallons.

The works have cost $80,000. The bonded debt is $75,000. Further financial statements are not given. The works are managed by a board of five trustees. John N. Gale is the Superintendent.

*The superintendent reports 200 barrels. This is extraordinarily small.

CCXXV.—LOGAN CITY.

Logan City, Utah, in lat. 41° 43′ N., long 112° W., is on the Logan River, which has a watershed of 150 square miles in the Wachusett Mountains. The town is on three plateaux, rising from the river, and is near the base of the mountains, which rise from 7,000 to 12,000 ft.

Settled in 1859, it was incorporated as a city in 1866.

Water-works were built by the city in 1878, after the plans and under the superintendence of James H. Martineau, C. E., taking the supply from the river 2½ miles above the town. An open canal, 20 ft. wide on bottom, and used for irrigating purposes also, conveys the water 1¾ miles. That used in the city is drawn then into a settling basin, in which the sand held in suspension is deposited. From this the water is carried 1,100 ft. in a conduit 12 by 16 in., of 2-in. pine plank, laid 5 ft. below ground, and also through a section of stone conduit laid in cement, to another settling basin. From this it is conveyed in pipes for 1,300 ft. to a reservoir 20 by 65 ft. and 12 ft. deep in 6 compartments, built in excavation, with stone walls 2 ft. thick laid in cement and with concrete bottom. The water passes through three compartments on either side of a central wall, with screens between them. Either side can be cleaned and drained while the other is in use. The reservoir is 108 ft. above the main part of the city and 180 ft. above the lower part. Distribution is by 1 mile of cast-iron pipe of 10-in. to 4-in. diameter, and 1 mile of 4-in. wooden pipe, bored out of solid Oregon pine, banded with iron and coated with coal tar. It is made in 8 ft. lengths. There are 13 fire hydrants, 2 gates and 11 taps. Service pipes are of galvanized iron.

The population in 1880 was 2,378 and the daily consumption 5,000 gallons.

The works cost $13,000. There is no debt.

The expenses of maintenance in 1880 were $100 and the receipts $300.

The works are managed by the City Council, with a superintendent, James Adams.

CCXXVI.—KENOSHA.

Kenosha, Wisconsin, in lat. 42° N., long. 88° W., is on the shore of Lake Michigan. The bank is from 8 to 15 ft. above the lake, and rises gradually for three miles westwardly to the divide between the Mississippi River and the lakes, 60 ft. above the lake.

Settled in 1835, it was incorporated as a city in 1850. Water-works were built in 1879 by a private company, after plans of Charles O'Connor, taking the supply from an artesian well of 4½-in. bore and 1,385 ft. deep. Rock was encountered at 90 ft. below the surface. The well is tubed with iron pipe for 185 ft. from the surface, and the pipe discharges directly into the mains, which are of cast iron of 6-in. to 3-in. diameter; 5½ miles are in use, with 27 fire hydrants, 12 gates and 380 taps. The city pays $33⅓ per year for each hydrant. Service pipes have been used of lead, galvanized iron and plain wrought iron. The last is rapidly destroyed by the water. The temperature of the water is 60° F. The free discharge of the well is estimated at 1,300,000 gallons per day. The head on the mains is ordinarily 20 to 30 lbs., and fire pressure 30 to 40 lbs. The population in 1880 was 5,043. The daily consumption is estimated at 400,000 gallons.

The capital stock of the Park City Water Company is $17,500. The works have cost $25,000, and the receipts have been about $6,000. There is no debt. The cost of maintenance is $800, and the receipts for 1881 were $3,100.

E. G. Hazelton is the Superintendent and the Business Manager.

CCXXVII.—STATE CENTRE, IOWA.

State Centre, Iowa, in lat. 42° N., long. 93° 4′ W., is on level ground on the plateau forming the divide between the Iowa and Skunk rivers.

Settled in 1859, it was incorporated as a city in 1869. Water-works were built in 1879 for the city, by the Batavia Wind Engine and Pump Company, taking the supply from two wells 58 ft. deep, and pumping by three deep-well pumps of 3-in. bore and 10½-in. stroke, operated by two windmills, into a wooden tank 18 ft. high, holding 80,000 gallons, and set on a frame 30 ft. above ground.

Distribution is by 1 mile of 6-in. cast-iron pipe, with 10 fire hydrants and 11 taps. Iron service pipes are used.

The population, in 1880, was 1,000. The consumption is not known.

The works cost $10,000. There is a bonded debt of $7,000, at 7 per cent. interest. The expenses in 1881 were $150, and the receipts $100.

The works are managed by a board of water commissioners. J. O. Cutler is the Superintendent.

[TO BE CONTINUED.]

The receipt of statistics, as follows, is acknowledged with thanks: From James H. Martineau, city engineer, statistics of water-works of Logan City, Utah. From R. H. Elam, superintendent, statistics of water-works of Pioche, Nev. From D. Allen, secretary, statistics and rates of water-works of Salem, Or. From Walter A. Osmer, city engineer, statistics of water-works of Logansport, Ind. From O. Z. Hamel, superintendent, statistics and rates of water-works of Three Rivers, Canada. From John C. Knowlton, water commissioner, statistics and rates of water-works of Watertown, N. Y. From P. L. Merritt, agent, statistics of water-works of Mission San Jose, Cal. From E. G. Hazleton, superintendent Park City Water Co., statistics and water rates of water-works of Kenosha, Wis. From the superintendent (who declines to give his name), statistics of water-works of Sidney, O. From J. O. Cutler, superintendent, statistics of water-works of State Centre, Ia. From George W. Howell, C. E., statistics of water-works of Salamanca, N. Y., and Warren, Pa. From John N. Gale, superintendent, statistics, water rates and annual report for 1881 of water-works of St. Johnsbury, Vt. From Eli W. Gilbert, secretary and acting superintendent, statistics of the water-works of Bethel, Conn. From Addison Lane, superintendent, statistics and water rates of the water-works of Melrose, Mass., and reports for 1869 to 1871 and for 1881. From George F. Bliss, superintendent, statistics of the water-works of Eureka, Nev.

CORRECTIONS.—Feb. 18, 1882, p. 58, *Hingham*, 7th line, for *reserving* read receiving. *Waverley*, 12th line, for *center* read *centre*; 14th line, for *breast wall* read *heart wall*. Feb. 25, p. 67, *Hannibal*, 4th line, for *by a private company* read *for a private company, by Carroll E. Gray*. 24th line, for 150,000,000 *gallons* read 1.500,000 *gallons*. 3d line from end, for 7 *per cent.*, read 8 *per cent.* Feb. 4, p. 39, *Greenfield, Mass.* A. A. Rankin writes that the capacity of the reservoir is 18,000,000 gallons, instead of 10,000,000 gallons, as he first reported. There are no water-works in the following towns, included in list of Jan. 28, taken from previous lists:

Ann Arbor, Mich.	Milford, Conn.
Dixon, Ill.	Reading, Mass.
Houlton, Maine	East London, Canada.
Worcester, Vt.	Beloit, Wis.

There are no towns, and consequently no water-works, of the following names in the States to which they are credited in the list of Jan. 28. The names were taken from newspaper items:

Greenville, Mass.	Crawfordsville, Pa.
Lagona, Ohio.	Susquehanna, N. Y.

To the list of water-works, add

Warren, Pa.	Salamanca, N. Y.

THE NATIVE PERSONNEL OF JAPANESE RAILWAYS.

The skill and ingenuity of the natives of Japan have long been well known, and another proof of their possession of these qualities is given by the aptitude which they display in learning the working of railways and qualifying themselves to fill the more responsible of the subordinate positions. The Japanese, from whom, for some time past, all the stationmasters and porters, as well as platelayers and artisans, had been drawn, have latterly been gradually replacing the English engine-drivers, and apparently with satisfactory results. The chief fault to be found with the native drivers is seemingly that they do not thoroughly understand the construction of the engines under their charge, but this is a matter which longer experience will rectify. There also appears to be a lack of presence of mind and watchfulness, and it is somewhat ludicrous to read of a driver starting with only half of his train in broad daylight, and not discovering the want of the other half until he had reached the next station. It is, therefore, not surprising that strict examination and supervision has to be kept on all engines under native drivers, in order to avoid any chance of failures or casualties. At the same time, we are assured that very few mishaps had occurred—indeed, so far as misadventures with the locomotives are concerned, the Englishmen appear to have been quite as often at fault as their native fellows—whilst the increasing number of Japanese employed bears testimony to the confidence which is felt in their capabilities. In other capacities the native workmen display great skill, the carriage and wagon building, for instance, being carried on in a highly satisfactory manner by the Japanese foreman carpenter; and two engines, which had been transferred from one line to another, having been put together again and got ready for work by a native fitter without any assistance from Europeans. The only complaint made against them is that they are somewhat slow. It is clear, however, that the Japanese are quite well enough qualified to carry on the working of their railways; and, after the system has been completed, we should not be surprised to find that eventually they took the entire control into their own hands.—*London Architect.*

CORRESPONDENCE.

ADJUSTMENT OF GRADES TO CURVES.

Continued from Page 71.

Vose, professor of civil engineering in Bowdoin College, in his "Manual for Railroad Engineers."

EQUIVALENT GRADE CURVE IN FEET PER 100 FEET.

	Scheffler.	Vose.	McClellan.
1°	0.044	0.045	0.05
2°	0.087	0.091	0.08
3°	0.131	0.136	0.12
4°	0.174	0.181	0.17
5°	0.218	0 226	0.22
6°	0.262	0.272	0.28
7°	0.305	0.318	0.33
8°	0.349	0.367	0.40
9°	0.392	0.409	0.47
10°	0435	0.456	0.54

Up to 7° the results agree pretty well with each other, but from hence the difference between second and third columns and fourth is growing rapidly, so that 18° gives:

Scheffler.	Vose.	McClellan.
0.78	0.856	1.54

As it is a fact that the resistance don't increase directly as the curvature, Mr. McClellan's formula is probably the most reliable, and it will be very interesting to learn his further experiments to test the correctness of his formula.

H. K. GLAHN, C. E.

CENTER OF GYRATION.

EDITOR ENGINEERING NEWS:

If when you consulted that "wiseacre" Rankine in answering your correspondent's query on this subject in your last issue, you had turned to page 515 of the work cited (Applied Mechanics), you would have been able to have better satisfied said correspondent's very laudable desire for knowledge, and perhaps have added somewhat to your own stock in trade.

Rankine there defines "radius of gyration" as "that length whose square is the *mean of all the squares* of the distances of the indefinitely small equal particles of the body from the axis, and is found by dividing the moment of inertia by the weight." Your correspondent may understand this better if you tell him that this means that distance at which if the entire weight is supposed concentrated in a single point, that point must be from the axis, *in order that the moment of inertia may be unchanged.*

It might be also well to call his attention to the fact that it is *only* with reference to rectangular and cylindrical cross-sections that we have $\frac{I}{h^2}$ — where h is the *least diameter*.

If you had looked along a little further to page 364, you would have found that for *other* cross-sections we must substitute for h^2 r^2, that is, the square of the least radius of gyration.

May I ask in my turn what is a "wiseacre?" One whose knowledge exceeds one's own, or one who thinks what he doesn't know isn't worth knowing?

[Came before EDITOR too late for answer.]

STADIA SURVEYING.

SANDUSKY, O., Feb. 23, 1882.

EDITOR ENGINEERING NEWS:

In the fifth number of volume 9 of your excellent paper is an interesting article by U. S. Assistant Engineer James P. Allen, on "Stadia Surveying." I believe that, outside of the U. S. Engineer Corps, very few surveyors have used this method, and the profession know but little about it, and hence do not properly appreciate its excellence. Having had occasion to survey a large body of coal lands where it was next to impossible to get anything like accurate chaining done, I resorted to the stadia plan. I have a Troughton & Simms theodolite with adjustable stadia wires placed horizontally, which, *with proper care*, gives excellent results.

As I believe in simplifying all my calculations, I have endeavored to carry this principle into the stadia method of measuring. In 1868 Mr. B. S. Lyman demonstrated that the proper place to commence counting was from a point as far in front of the objective glass as the focal length of that lens. In my instrument this distance, from the center of the instrument, is 1.25 ft., which is generally used as a constant to be added to each observed distance. This is but a small matter; but it is just as well to get rid of it. I avoid this difficulty in a very simple manner. I use a nicely divided leveling rod with two targets; the lower one, instead of reading zero, is fixed when observing for distance, at 0.0125. Then, while the lower wire is on this target, the upper target is moved to the precise places cut by the upper wire. So that I get at once the precise distance from the center of the instrument to the observed station.

To adjust the wires, I measure accurately between two pegs—say 300 ft. I set my instrument 1.25 ft. back of the starting point, and set my lower target at 4.5 ft. and the upper at 6 ft. Then I use my center wire, and each of the movable wires is adjusted so as to read precisely 1.5 ft. from the center line. Then set the lower target at 3 ft., leaving the upper one at 6 ft.; and the stadia wires must cut the centers of the targets.

Another matter, which I do not see noticed in any work except Nickell & Strassberger's catalogue, viz., that, in reading the rod, for distance, it should be held at right angles with the line of sight. In the English plan this is accomplished by holding the stadia rod in a horizontal position, while the wires are vertical. I have my rod-man carry a square, with small sights, which he applies to the rod, and leans the rod back or forward so that the line of the sights on the square will strike the telescope. Perhaps this is understood by engineers generally; but as it may not be by some of the young members, I thought it best to call attention to it.

Of course to get the vertical angle, the vertical height of the center of the glass above the nail at the station is measured; and then the rod is held plumb at each nail, with the target at the height of instrument, and the vertical angle measured while in that position. Indeed, that is the first thing I do before moving the target for distance.

I place my stations at every change of surface, and number them from 0 to the end of each line and sight first for vertical angle, and then for distance at each station as far as I can get distinct vision. I then move forward to the last station (or to such station as may prove to be a proper turning point), measure height of instrument, have a stadia rod held at my last turning point, and test for vertical angle and distance. Then I go ahead again as far as I can see clearly.

My horizontal limb is divided to 360°. And I keep the body parallel to either the magnetic or an assumed meridian, and, of course, can lay off any other line or lines in any direction from the instrument, and in this way get the contour lines very nicely.

In reducing my work I do not trust to any graphical construction. I use the best tables of cosines and sines, and reduce every observation in that way. The graphical plan may do for intermediates, but I certainly would not trust it for turning points.

If these hurried statements will be of service to any of our younger brothers, make such use of them as you think proper.

GEORGE MORTON, C. E.

THE STANDARD METRIC CHAIN.

BOSTON, Feb. 15, 1882.

EDITOR ENGINEERING NEWS:

In a previous communication the writer endeavored to show that the *double-dekameter*, or twenty-meter measure, is eminently adapted to be used in extensive engineering operations from the fact that, in its total length, it is one of the standard series of metric linear measures, and that, in common with every measure of that series, it possesses the valuable property that every smaller metric unit is an aliquot part of it, while it is itself an aliquot part of every larger metric unit.

The *double-dekameter* also possessed some peculiar properties which render it equally well adapted to the details of surveys. Being an assemblage of twenty units it can be divided into 2, 4, 5, 10 or 20 equal parts without requiring the use of fractions of the unit; its eighths, moreover, merely require the use of the fraction 0.5, while its hundredths are expressed in meters by the simple decimal 0.2 and its multiples.

These properties are valuable in the details of surveys where a series of equi-distant offsets are required, the distance between which shall be an aliquot part of the total length of the measure employed, as is the case where railroad curves are laid out by offsets from the chord, and in some other instances.

It is desirable that a table should be published, giving, in meters, the radii, tangent deflection, chord deflection and ordinates of curves of different degrees of curvature, corresponding to a chord of 20 meters. Until such a table shall have been published, the ordinary tables may, however, be used by a simple modification.

The ordinary tables being computed for a chord of 100 units, the various values contained in them are the values in meters corresponding to a chord of 100 meters, and they could be used in their present form were it practicable to use so long a chord.

The hundredth part of twenty meters being 0.2m., and of ten meters 0.1m., we may use the following rule:

To convert the values for the radii, tangent and chord deflections and ordinates for curves given for chords of 100 ft. into the corresponding values in meters for chords of 20 meters, multiply the tabular values by two, and move the decimal point one place to the left; to find the values in meters for a chord of ten meters, move the decimal point one place to the left.

In order to most conveniently reach the decimal subdivisions of the meter, metric surveying chains are constructed with *five* links to the meter. The French chains are made with a *brass* ring at each meter, instead of the iron rings used on the rest of the chain, and a tag is placed at every *fifth* meter. This arrangement requires a considerable length of the chain to be examined at each partial measurement, which is inconvenient. A more perfect arrangement has been recently introduced by the Messrs. Gurley, of Troy. On a twenty meter chain of their manufacture in the possession of the writer, a tag is placed at each meter. These tags are numbered from 1 to 20, continuously, from one end of the chain; the central tag, however, is larger than the others, and is marked in full, thus: "10 meters—1 dekameter." The chain is made with five links to the meter, or 100 links altogether.

This marking of the central tag is valuable both because the dekameter seems likely to be used as the unit for numbering the stations on railroad work and because it is a constant reminder, in the field, that the chain length is a double measure, and that distances are not to be given in terms of it, but rather in terms of some metric unit. To state distances in terms of a double measure is more reprehensible with metric measures than it would be with the old measures. Yet, with them, lengths are never stated in terms of the two-foot rule, but always in terms of the unit, the foot.

The practice, when applied to the 25 meter chain, as has been done in Mexico, requires that 25 shall be continually borrowed or carried after the fashion of the old British denominations.

To perpetuate these methods after the adoption of the metric measures will be to sacrifice the most important benefits that may be gained by their proper use.

In justice to the profession it should be said that the confusion now existing on the Mexican roads is largely due to the abruptness with which the metric measure was demanded. Work had to be adapted to an unfamiliar system of measures under the pressure of actual construction. Dealers in engineering supplies were unexpectedly called upon to furnish large quantities of metric measures at a day's notice. Heterogeneous outfits, confusion and disappointment, are the natural sequences of such conditions.

It is to be hoped that upon the completion of work already systematized the profession will abandon all imperfect implements and methods, and uniformly adopt those that are thoroughly based upon sound decimal principles, and are therefore able to develop the application of the metric system in all its simplicity and beauty.

The most important features are:

1. The uniform use of the double-dekameter, or 20 meter measure, in field work.

2. The use of 20 meter stations and 20 meter chords on ordinary work; numbering the stations from an initial point in terms of some one of the metric units, preferably the dekameter.

3. The exclusive use of the standard series of metric draughting scales, which embraces the scales 0.002, 0.0025, 0.003, 0.004, 0.005, 0.006, 0.008, 0.010, 0.015, and their decimal derivatives.

4. The exclusive use of profile and cross-section paper whose rulings are based upon the half centimeter, the centimeter, or the double centimeter.

Of less vital importance, but of great practical utility may be mentioned:

5. The leveling rod, on which the figures indicating units are repeated at every decimeter, forming with the other figures a continuous numbering in decimeters.

6. Ranging poles 3 meters long marked in bands 0.5 meter wide, or 2 meters long marked in bands 0.2 meter wide.

An engineer supplied with the outfit here described can execute metric work according to the most approved methods.

CHARLES M. SWAN, C. E.,
Chairman of the Committee on Manufactures of the American Metric Bureau.

ARTIFICIAL BALLAST.

NEW YORK, March 1.

EDITOR ENGINEERING NEWS:

Will some of your readers please give the method of making artificial ballast of burnt clay for railroad purposes, or a reference to some description of its use in American or European practice?

A. B. C.

DYNAMICAL.

CHICAGO, Feb. 16, 1882.

EDITOR ENGINEERING NEWS:

We would like to have you decide the following wager: There is a safe in the corner of the office. A bets he can lift that safe. B bets he cannot lift the safe. Please let us know if A be allowed any implements to lift the safe with, or has he to do it by bodily strength. Inclosed find stamp for return mail. Hoping to hear your decision, we remain, respectfully, EMPLOYES OF ——.

[It should be raised at arm's length by bodily strength only, like a dumb-bell.—ED. ENG. NEWS.]

[A is entitled to use any *safe* means whereby *his* muscular exertion alone is exercised in the performance of the feat.—THE OTHER EDITOR.]